Haimeng Zhao

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Education

- **Tsinghua University** — Beijing, China
  B.Sc. in Physics & Maths, Minor in Statistics, Advisor: *Dongling Deng*, *Wei Zhu* — 2020–2024(Expected)
  GPA: **3.96/4.00**, Major GPA: **4.00/4.00**; English: TOEFL 113/120 (25/Speaking), GRE 335/340
- **EPFL (École Polytechnique Fédérale de Lausanne)** — Lausanne, Switzerland
  Exchange, GPA: **6/6** (4 grad courses), Advisor: *Giuseppe Carleo* & *Filippo Vicentini* — 2022 Fall
- **California Institute of Technology** — Pasadena, CA, USA
  Undergrad Research Fellow @ IQIM, Advisor: *John Preskill* & *Matthias Caro* — 2023 - Now

Research Interest

- How to better understand the universe,
and how is understanding even possible?

- Quantum Information, Statistics & Learning Theory
- AI for Science, especially Physics & Astrophysics
- Quantum Many-body Physics: Theory & Computation
- Generative Learning, Neural Differential Equations

Skills

- **Computational Physics:** (Quantum) Monte Carlo, DFT, Tensor Network, Neural Quantum States. NetKet and NASA EMAC contributor.
- **(Quantum) Machine Learning:** (Quantum) Learning Theory, Variational Quantum Algorithms, Generative Learning, Neural Differential Equations.
- **Programming:** High performance scientific computing with Python & C++. Differentiable programming with JAX, PyTorch (6 years) & TensorFlow.

Selected Publications

1. **Zhao, H.,** Carleo, G. & Vicentini, F. Empirical Sample Complexity of Neural Network Mixed State Reconstruction. Submitted to *Quantum*. arXiv: 2307.01840 `[quant-ph]` (2023).
2. **Zhao, H.** Non-IID Quantum Federated Learning with One-shot Communication Complexity. *Quantum Machine Intelligence* **5,** 3. arXiv: 2209.00768 `[quant-ph]` (2023).
3. **Zhao, H.** & Zhu, W. MAGIC: Microlensing Analysis Guided by Intelligent Computation. *The Astronomical Journal* **164,** 192. arXiv: 2206.08199 `[astro-ph.IM]` (2022).
4. **Zhao, H.** & Zhu, W. Parameter Estimation in Realistic Binary Microlensing Light Curves with Neural Controlled Differential Equation. *ICML 2022 Workshop on Machine Learning for Astrophysics* (2022).
5. Liu, J., Tang, Y., **Zhao, H.,** Li, F. & Zhang, J. CPS Attack Detection under Limited Local Information in Cyber Security: An Ensemble Multi-Node Multi-Class Classification Approach. *ACM Transactions on Sensor Networks.* arXiv: 2209.00170 `[cs.CR]` (2023).

Selected Research Experience

- **QAI: Fundamental Limitations on Learning Physical Processes** — Feb. 2023 - Now
  Advisor: John Preskill & Matthias Caro, IQIM @ Caltech
  - Established information-theoretic lower bounds on sample complexity of learning T-gate local unitaries.
  - Established a genuine quantum no free lunch theorem compatible with entangled and mixed data.

- Established exponential separation between learning from classical descriptions and quantum data.

- **AI4Q: Sample Complexity of Neural Quantum State Tomography** Aug. 2022 - Jul. 2023
  Advisor: Giuseppe Carleo & Filippo Vicentini, Computational Quantum Science Lab @ EPFL **First Author [1]**
  - Introduced control variates to control gradient variance and significantly reduce sample complexity.
  - Conducted extensive numerical & theoretical studies to understand different sample complexity behavior.
  - Benchmarked different tomography methods and propose to design quantum-resource-efficient NQSs.

- **AI4Astro: ML Framework for Realistic Microlensing Event Analysis** Oct. 2021 - Sep. 2022
  Advisor: Wei Zhu, Department of Astronomy @ Tsinghua **First Author [3, 4]**
  - Introduced U-Net and neural controlled differential equations to parameter estimation of microlensing.
  - Developed a machine learning framework for irregular astronomical time series, listed on NASA EMAC.
  - Accelerate microlensing analysis by $\times 10^5$ and successfully applied to real events for the first time.

- **QAI: Non-IID Quantum Federated Learning** Aug. 2022
  Single authored work. Extending [5] to the quantum regime. **Single Author [2]**
  - Proposed and studied the non-IID quagmire in quantum federated learning, theoretically & numerically.
  - Extended [5] to a quantum algorithm. Conducted extensive numerics to show its robustness and efficiency.

Selected Coursework

* for graduate courses.

High-dimensional Probability*	A	Quantum Artificial Intelligence*	A
Interacting Quantum Matter*	6/6	Stat. Phys. of Computation*	6/6
Information Theory and Coding*	6/6	Biophysics*	6/6
Computational Quantum Physics*	A+	Solid State Physics	A+
Atom and Molecule Physics	A	General Relativity	A
Analytical Mechanics	A	Quantum Mechanics	A
Statistical Mechanics	A	Electrodynamics	A+
Complex Analysis	A+	Partial Differential Equations	A+

Self taught: Quantum Field Theory, Lattice Field Theory, Topology, Group Theory, Theoretical Computer Science, Quantum Information Theory.

Scholarships and Awards

- Caltech Summer Undergraduate Research Fellowship 2023
- National Scholarship (National Highest Honor for Undergrads) 2022
- Scholarship of the National Astronomical Observatory of China 2022
- Chi-sun Yeh Scholarship (Highest Honor for Physics Major), Tsinghua Xuetang Talents Program 2020–2022
- Dean's Award (Highest Honor from Department) 2022
- Scholarship of Comprehensive Excellence, Tsinghua University 2020–2022
- S.-T. Yau College Maths Contest, Silver Medal (2^{nd} place) in Mathematical Physics 2022
- S.-T. Yau High School Science Award, Gold Medal (1^{st} place) in Computer Science 2019
- National Awarding Program for Future Scientists, 1^{st} place 2019
- Chinese Physics Olympiad, Bronze Medal 2019